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mals are very much alike, being frequently started under an old log and continuing under the same for its entire length.

They do not hibernate, but keep their burrows open all winter; beaten trails in the snow are often seen, leading above ground for a few feet, from one hole to another. They are able to gather their food at any time of the year, seldom going more than a few feet from the entrance of their holes to procure it.

I have never heard them make any kind of noise by day or night, save a kind of growl when caught in a trap. They are easily caught in steel traps, to the contrary of what many with whom I have conversed assert. I have caught numbers of them without even covering the traps. The No. 0 "Newhouse" trap is the one I have used. They are quite strong, and generally break their legs; and, if long in the trap, will be found dead.

A friend of mine had one domesticated for several months. It readily ate apples and other fruit, vegetables, etc., and seemed to bear confinement very well. It took great pleasure in paddling in a dish of water; slept most of the time during the day, but awakened to activity as night came on. Another man caught one while young, and let it run about the house. As it grew larger it dug a hole in the ground near the well, where it lived contentedly for a long time, when a strange dog killed it.

My knowledge respecting the breeding of the show'tl is limited and uncertain. People living in the vicinity of these animals tell me that the young show'tls just weaned make their appearance during the month of June, in numbers from three to five at a birth. The females have six teats. From my present knowledge of them I suspect they breed but once a year, like the beaver.*

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THE MICROSCOPE AS A MEANS OF EXAMINATION OF ROCKS AND FOSSILS.

BY DR. R. FRITZ-GAERTNER.

THE examination of rocks in regard to their lithological character is accompanied with great difficulties whenever their composing minerals are so minute and so thoroughly intermingled

* On the habits of this animal compare also: *Coues*, Monograph of Rodentia of North America, 1877, pp. 590-598; *Matteson*, Am. Nat. XI, 1877, pp. 434, 435; Murphy, London Field for May 5, 1877.—E. C.

with each other that one even by aid of the magnifying glass cannot recognize them.

A compound rock of such minute structure may appear to be a homogeneous one, as the individuality of its minerals is lost, in comparison with the whole appearance of the rock. The chemical analysis of the compound will not furnish an adequate representation of its mineralogical composition, but will only give some figures of its elements, after which we classify the rock under examination by comparison with a group of rocks, with which it has the greatest resemblance in its chemical composition. At the same time we have to remember that there are rocks which are of the same chemical composition, and yet their mineralogical constituents are different from each other. True, chemical investigation has helped us to gain some valuable points according to which we may form some idea of the composing minerals, but not of their physical qualities, *i. e.*, in which state of molecular arrangement they may be, and how they adhere to each other. Chemical analysis is therefore not a complete survey of the lithological nature of the rock; the task laid upon chemistry by lithology was too heavy, as the former destroys the architecture of our mineral aggregate, instead of examining it. We should therefore not wonder that this result of chemical investigation could not be used as a firm basis for lithology and geology.

A great number of rocks, mineralogically different from each other, were treated and named according to their chemical composition as one kind of rock, whilst lithology on the other hand unnecessarily enriched its nomenclature by giving to one and the same rock (the structure of which presented itself in various forms) different names.

The study of palæontology without the aid of the microscope was limited, as it could only treat, in its description, of facts visible to the eye. We know by experience that nature by the process of petrification has not only preserved the macroscopical forms and organs of those fossil organisms, but also their microscopical one. These minute remains whether only organs of a macroscopical fossil or an organism by itself, rightly deserve to be studied with the same industry and endurance, with which their larger fellow organisms are favored; the more, as we know that the microscopic organic world takes and has taken an important position as architects of the sedimentary rock of our earth. The researches of the palæontologist enable him to meet

with forms of which it is difficult to decide without the aid of the microscope and some preliminary preparation of his material, whether they have to be treated by the lithologist or palæontologist. A chemical analysis will not disclose their origin, whether by mineral accumulation or organic life. Usually they are left to the lithologist who, not long ago, claimed all the fossils as freaks of nature. A great number of those interesting forms are generalized with oolites, concretions, etc. The unsatisfactory results obtained by the limited macroscopical and chemical analysis of rocks and fossils, induced Dolomien and Cordier in the last century to advocate the use of the microscope as a necessary and important instrument for investigations in geology. But their efforts failed to secure to the microscope an acknowledged position in the laboratories of the lithologist and palæontologist. This failure has to be principally attributed to their defective mode of preparing the rocks for the microscope. The examination of the rock consisted mainly in viewing its natural fracture or polished surface by aid of reflected light, as the opaqueness of the material did not allow the use of a transmitted light. This imperfect method could not be of much service.

Another method of preparing rock material for the microscope was to crush it to a fine uniform powder, which by decantation with water was deposited according to its specific weight. The minerals composing a compound rock being of different specific weight, they separated in beds or layers, which contained principally one and the same mineral. The minuteness of the powder allowed it to be viewed under the microscope with transmitted light. In most cases the minerals could be recognized either by means of the magnifying power or by aid of chemistry, which analyzed the separated layers by themselves, but which in reality do not always consist of fragments of the same kind of mineral, but are also partially mixed up with each other. The chemical analysis could not be entirely depended upon, but had to be verified by microscopical observation. The greatest drawback to this method of rock analysis is the entire loss of structure during the grinding process. And although Ehrenberg, by this method of examining rocks in form of dust, achieved his famous results of the micro-fossil organs of the chalk formation, yet the microscope remained for a long time of only limited use.

The great reorganization of lithology which has recently been

accomplished by Sorby, Zirkel and Rosenbush may be attributed to the introduction of thin sections of rocks for microscopical analysis. These sections are ground thin enough to allow the use of transmitted light, and although but a small slice of a rock be examined, it reveals their composing minerals and their structure and also their accessory aggregates.

The structure and means of cementing of rocks is clearly represented in the various sections made in various directions.

The base of a rock is by aid of the polariscope readily deciphered, whether it be crystalline or amorphous. The base of porphyry is composed of minute particles of feldspar and quartz. Basalt was found to contain sometimes enclosures of a glassy character, which in many cases are so large that they assume the aspect of a base through which the crystalline part is scattered, and rocks which were always considered as amorphous, were shown by aid of thin sections to be in a state of crystalline formation.

One of the most interesting features of lithology is the chapter treating of the cause and result of metamorphic changes in rock. A section of an altered rock presents in itself the whole story of a process which for a long series of years must have been working to produce a chemical and physical alteration in those solid bodies. We learn by the study of the thin section with the microscope, which of the composing minerals was at first disturbed and changed, and how the progress of change in the molecules was gradually spread through the whole mass. The well-known rock, serpentine, may illustrate this. A section presents outlines of crystals which are on the borders serpentine, but which in their centre enclose a clear and unaltered nucleus of chrysolite, the remainder of the chrysolite crystal, the form of which is preserved in serpentine. Further, basalt carries chrysolite as one of its most common accessory minerals. Nearly all these chrysolites are in a state of metamorphism, their outlines showing bands of serpentine, similar in structure to the serpentine occurring in large masses and the origin of which has been found to be in a compound rock changing by the chemical and physical alteration to a homogeneous one.

A careful microscopical study of rocks and minerals of a country enables us also to trace the original rocks which furnished those immense layers of drift clay, which when prepared for the

microscope appears as a mass of debris of rocks altered by mechanical means and pseudomorphical actions.

The study of thin sections of rocks has also widened our knowledge of the more frequent occurrence of certain minerals as micro-mineralogical accessories, as magnetite, menaccanite, apatite, hornblende, tourmaline, nepheline, nosean, microlites, and many others.

It is also due to microscopical researches that crystallography and mineralogy have been abundantly enriched in facts which may be of the greatest importance for their development as sciences. What we formerly thought to be a single crystal has shown itself as a number of crystals in position of twin formation. A great number of crystals, principally quartz, have been found to be porous, the pores filled with liquid, most likely water and carbonic acid, and these pores are the most frequent if quartz occurs in granite or syenite.

Orthoclase presents under the polariscope two systems of bands crossing each other at right angles. Labradorite is filled with menaccanite and magnetite; and mica and magnetite generally pierced with apatites when occurring in granites, or in diorites.

It is not the intention of the writer to describe all those results of micro-lithological researches which within a few years have re-organized lithology and richly contributed to geology, mineralogy and crystallography. The remarkable work of Prof. Zirkel, forming the sixth volume of the Report of the United States Geological Exploration of the Fortieth Parallel, under the direction of Prof. Clarence King, Geologist-in-charge, will demonstrate at once the importance of thin section in lithological researches.

Palæontology likewise has derived a great many new facts, as will be seen in a forthcoming volume of the "Palæontology of the State of New York," by Prof. James Hall. A great number of sections of corals and sponges and other fossils have been prepared and illustrated. The result derived from its perusal will show that palæontology also has progressed as much as lithology by the adoption of thin sections and the microscope as a means for the study of fossils.